REMARKS

Claims 1-5 and 7-19 are all the claims presently pending in the application. Claim 6 was withdrawn from consideration and is herein canceled, further to a provisional (oral) restriction requirement election made without traverse, so that the invention of the remaining claims (claims 1-5 and 7-19) can be prosecuted. Claims 1-5 have been amended to more particularly define the invention. Claims 7-19 have been added to claim additional features of the invention.

It is noted that the claim amendments are made only for more particularly pointing out the invention, and not for distinguishing the invention over the prior art, narrowing the claims or for any statutory requirements of patentability. Further, Applicant specifically states that no amendment to any claim herein should be construed as a disclaimer of any interest in or right to an equivalent of any element or feature of the amended claim.

Claims 1-5 stand rejected under 35 U.S.C. § 102(e) as being anticipated by Nakamura, et al. (U.S. Patent Application Publication No. 2002/0020229 A1).

The rejection is respectfully traversed in the following discussion.

I. THE CLAIMED INVENTION

The claimed invention is directed to a rotation angle detecting device and a torque detecting device, which can prevent waveforms outputted from a plurality of semiconductor MR elements from dispersing due to a material difference in a semiconductor wafer. By the present invention, a plurality of semiconductor MR

elements are formed over a common cell of a semiconductor wafer and are arranged to face a magnetic member at such positions different from each other in a target circumferential direction with respect to corresponding input and output shafts that signals to be outputted according to the rotations of the input and output shafts that are to be detected may establish a predetermined phase difference in an electrical angle.

It is conventional for a rotation angle detecting device to use semiconductor MR elements, but, due to a material difference of the semiconductor MR elements, the outputs of two channels of the two semiconductor MR elements may fail to have identical waveforms that differ from each other only by phase. More specifically, in such a conventional detecting device, either two sensor chips of different rod numbers of the semiconductor wafer or two sensor chips formed in cells at spaced positions over a common wafer are combined and used as the MR element of the two channels. Therefore, these MR elements of two channels may not have identical electrical characteristics, such as temperature characteristics, due to the material difference of the MR elements. In case the MR elements are shifted in the circumferential direction of the targets, the waveforms of the outputs of the two channels may be different not only in phase, but also in amplitude or the like.

In the claimed invention, on the other hand, the magnetic sensors include, respectively, semiconductor MR elements that are formed over and integrally with a common cell of a semiconductor wafer. As a result, waveforms outputted from a plurality of semiconductor MR elements can be prevented from dispersing due to a material difference of a semiconductor wafer.

In one exemplary embodiment of the present invention, all the MR elements a1 to

a3 and b1 to b3 of the six channels contained in the sensor units P, Q and R illustrated in the drawings can be integrally formed over the common cell Wc of the wafer W. As a result, it is possible to make uniform the electric characteristics, such as temperature characteristics, in the MR elements a1 to a3 and b1 to b3, and to prevent the output waveforms of the magnetic sensors A1 to A3 and B1 to B3 from dispersing due to the material difference of the semiconductor wafer W. As a result, the output waveforms of the respective magnetic sensors A1 to A3 and B1 to B3 can be adjusted by the same method (or with the same adjusting value) so that the adjusting work of the sensor outputs can be done easily.

Moreover, since this embodiment uses the MR elements a1 to a3 and b1 to b3 of six channels formed integrally over the common cell Wc, the respective mutual distances between the magnetic sensors A1 to A3 and the magnetic sensors B1 to B3 in the circumferential direction of the target can be regulated by the size d1 in the common cell and can be reliably retained at the desired distance. As a result, the sensors A1 and B1 for two channels can be precisely arranged without any dispersion in the parallelism between the magnetic sensor A1 and the magnetic sensor B1 and in the azimuth angle in the respective sensors. Moreover, the MR elements a1 to a3 and b1 to b3 for the six channels are mounted by using one substrate 14 and one magnet 12, so that the distances (i.e., the air gaps) between the respective magnetic sensors A1 to A3 and B1 to B3 and the corresponding targets 34 to 36 can be easily equalized to prevent the strain, as might otherwise be caused due to the difference in the air gaps, from appearing in the sensor output waveforms. Attention is directed to page 19, line 11 - page 20, line 3 of the specification.

Moreover, the respective positioning works of the magnetic sensors A1 to A3 and B1 to B3 with respect to the targets 34 to 36 can thus be easily done to detect the respective rotation angles of the input and output shafts 32 and 33 and the steering torque and steering angle to be applied to the steering member 1, in the desired detecting precision. Therefore, the steering assisting force can be properly decided according to the steering operation of the driver, and the adjusting work of the sensor output can also be easily done, thereby to simplify the assembling work of the detecting device and accordingly the steering device (page 20, lines 3-14 of the specification).

In this embodiment, moreover, the paired MR elements a1 to a3 and b1 to b3 for the respective targets 34 to 36 are arranged over the common cell Wc and at the circumferential positions different from each other with respect to the corresponding input and output shafts 32 and 33. Therefore, the paired MR elements a1 to a3 and b1 to b3 can output a plurality of identical waveforms different from one another only by phase in accordance with the respective rotations of the input and output shafts 32 and 33 so that they can output the signals of a predetermined phase difference in the electrical angle (page 20, lines 15-24).

There has been described the construction in which all the MR elements a1 to a3 and b1 to b3 of six channels are formed in the common cell Wc. However, the invention is not limited to that construction but also includes a plurality of magnetic sensors each including a plurality of semiconductor MR elements, such that the irregularities of the electric characteristics, as might otherwise be caused due to the material difference of the semiconductor wafer, are eliminated by forming those semiconductor MR elements integrally over the common cell. More specifically, for example, the MR elements (e.g.,

the MR elements a1 and b1) for two channels for each target may be integrally formed over a common cell. Alternatively, every two MR element units (e.g., the MR elements b2 and b3) arrayed in the axial direction may be integrally formed over a common cell (page 21, lines 10-24).

In view of the preceding paragraph, the proposed Amendment proposes amending claims 1 and 4 to call for at least some of the semiconductor MR elements to be formed over and integrally with a common cell of a semiconductor wafer. It also proposes adding claims 7-19 to claim other features of the invention, claim 13 to be similar to claim 1 but recite the target in broader terms, and claims 15-19 to depend on claim 13 and recite additional features.

II. THE PRIOR ART REFERENCE

The Nakamura, et al. Reference

The Examiner alleges that Nakamura, et al. teaches the claimed invention. We believe, however, that there are elements of the claimed invention which are neither taught nor suggested by Nakamura et al.

Nakamura et al. discloses a cylindrical rotating member provided with a magnetic element, on the outer surface thereof, that is led around the rotating member by one turn and is at an angle relative to the rotating direction of the rotating member in an approximately linear manner. End portions of the magnetic element are disposed at approximately the same position in the radial direction of the rotating member. Magnetoresistive elements are arranged in a direction perpendicular to the rotating direction of the magnetic element (in other words, axial direction of the rotating member) with a gap therebetween and opposite the magnetic element.

However, Nakamura et al. fails to disclose the feature of the rejected claims that the semiconductor MR elements are formed over and integrally with a common cell of a semiconductor wafer. Although the Examiner states near the top of page 4 of the Office Action that the semiconductor MR elements of Nakamura et al. are formed over and with a common cell of a semiconductor wafer and refers to element 23 and Fig. 3, Fig. 3 shows only one MR element, element 21, and does not include MR element 22 or any other MR element. Paragraph 0055 of Nakamura et al. states that only MR element 21 is shown in Fig. 3. Paragraph 0055 makes clear that MR element 22 is like element 21, but has its own substrate, pattern and electrodes. Nothing suggests that the MR elements 21 and 22 of Nakamura et al. are formed over or integrally with the same cell of a semiconductor wafer.

Most of the discussion at the top of page 4 of the Office Action refers to Fig. 17 and MR elements 121 and 122. However, like the MR elements 21 and 22, nothing in the Nakamura et al. reference discloses or suggests that the MR elements 121 and 122 shown, for example, in Fig. 17 are formed over and integrally with a common cell of a semiconductor wafer.

Therefore, we believe that there are elements of the claimed invention that are not taught or suggested by Nakamura et al., and we propose to request the Examiner to withdraw this rejection.

In addition to the differences already discussed, there are other differences between the present invention and the disclosure of the Nakamura et al. reference. The targets of the present invention include corrugations (page 14, line 11). This feature is claimed in new claims 11, 12, 18 and 19. In contrast, Nakamura et al. discloses magnetic

elements 13 and 73 at an angle in an approximately linear manner (paragraphs 60 and 79).

III. FORMAL MATTERS AND CONCLUSION

In view of the restriction requirement and the non-election of the method claim, the proposed Amendment proposes amending the title to be more indicative of the invention to which the claims pertain and to overcome the Examiner's objection to the title. More specifically, the amended title omits reference to the method of manufacturing.

In view of the foregoing, Applicant submits that claims 1-5 and 7-19, all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully submitted,

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